5243

ORIGIN AND EVOLUTION OF ITOKAWA REGOLITH PARTICLES BASED ON THREE-DIMENSIONAL SHAPES AND SIZES OF HAYABUSA SAMPLES

A. Tsuchiyama[1], M. Uesugi[2], T. Matsushima[3], T. Michikami[4], T. Kadono[5], T. Nakamura[6], K. Uesugi[7], T. Nakano[8], S. A. Sandford[9], R. Noguchi[1], T. Matsumoto[1], J. Matsuno[1], T. Nagano[1], Y. Imai[1], A. Takeuchi[7], Y. Suzuki[7], T. Ogami[6], J. Katagiri[3], M. Ebihara[10], T. R. Ireland[11], F. Kitajima[12], K. Nagao[13], H. Naraoka[12], T. Noguchi[14], R. Okazaki[12], H. Yurimoto[15], M. E. Zolensky[16], T. Mukai[2], M. Abe[2], T. Yada[2], A. Fujimura[2], M. Yoshikawa[2] and J. Kawaguchi[2]. [1]Department Earth & Space Science, Osaka University, Osaka, Japan. E-mail: akira@ess.sci.osaka-u.ac.jp. [2]JAXA. [3]Department Engineering Mechanical & Energy, University of Tsukuba, Tsukuba, Japan. [4]Fukushima National College of Technology. [5]ILE, Osaka University, Osaka, Japan. [6]Department Earth & Planetary Mat. Science, Tohoku University, Tohoku, Japan. [7]JASRI/SPring-8. [8]GSJ/AIST. [9]NASA ARC. [10]Graduate School of Science & Engineering, Tokyo Metropolitan University, Tokyo, Japan. [11]Research School of Earth Science, ANU. [12]Department Earth & Planetary Science, Kyushu University, Kyushu, Japan. [13]Geochemical Research Center, The University of Tokyo, Tokyo, Japan. [14]The College of Science at Ibaraki University, Ibaraki, Japan. [15]National History Science, Hokkaido University, Hokkaido, Japan. [16]NASA JSC.

Introduction: Particles of S-type asteroid 25143 Itokawa were successfully recovered by the Hayabusa mission, and at least 1500 recovered particles have been identified as having an Itokawa origin [1, 2]. This is the first sample recovered from an asteroid and returned to Earth, and the second extraterrestrial regolith to have been sampled, the first being the Moon, which was sampled by the Apollo and Luna missions. We obtained three-dimensional (3-D) structures of Itokawa particles using X-ray microtomography in the Hayabusa sample preliminary examination in order to understand their textures in comparison with meteorites and the 3-D shape features in connection with the regolith formation and evolution on the asteroid [2].

Experiments: Forty particles of approximately 30–180 μm in size were imaged at BL47XU of SPring-8 with effective spatial resolutions of approximately 200 or 500 nm. Imaging at two X-ray energies of 7 and 8 keV made identification of minerals in CT images possible. A successive set of 3-D CT images, which shows quantitative 3-D mineral distribution, was obtained for each particle.

Results and Discussion: Modal mineral abundances of the whole sample and the bulk density ($3.4\ g\ cm^{-3}$) calculated form the modal abundance and average chemical compositions of the minerals [1] are similar to those of LL chondrites. 3-D structures of the particles having textural variations indicate a mixture of equilibrated and less-equilibrated chondrite materials. No particles showing melting were observed, indicating low impact velocities similar to typical relative impact velocities among asteroids (approximately $5\ km\ s^{-1}$). 3-D shape features of the particles (size and shape distributions together with presence of particles with rounded edges) suggest that they were formed by meteoroid impacts on the asteroid surface, transported to the smooth terrain, and eroded in situ there by granular processes, which include major resurfacing processes in small asteroids [3]. The above discussion indicates that the returned sample roughly represents the general surface materials on Itokawa.

References: [1] Nakamura T. et al. 2011. Abstract #1776. 42nd Lunar and Planetary Science Conference. [2] Tsuchiyama A. et al. 2011. Abstract #1777. 42nd Lunar and Planetary Science Conference. [3] Miyamoto H. et al. 2007. *Science* 316:1011–1014.

5103

EVIDENCE FOR EXTINCT ^{36}Cl FROM EXCESS ^{36}Ar IN ALLENDE SODALITE

G. Turner[1], R. Burgess[1], S. P. Kelley[2] and G. J. Wasserburg[3]. [1]SEAES, University of Manchester, UK, E-mail: Grenville.turner@manchester.ac.uk. [2]Dept. of Earth and Environmental Science, Open University, UK. [3]Division of Geological and Planetary Science, California Institute of Technology, USA.

Introduction: Excesses of ^{36}S have previously been reported in sodalite ($Na_8Al_6Si_6O_{24}Cl_2$) and wadalite ($Ca_6Al_5Si_2O_{16}Cl_3$) in CAI and chondrules from the Allende and Ningqiang meteorites and used to infer the presence of ^{36}Cl (half-life 3×10^5 a) in the early solar system [1–3]. In spite of the fact that ^{36}Cl decays predominantly (98%) to ^{36}Ar, all attempts to locate the very large amounts of ^{36}Ar implied by these ^{36}S excesses have been negative. Here we present results of a new method to identify ^{36}Ar from ^{36}Cl decay, based on low fluence fast neutron activation.

Method: We have irradiated two batches of Allende sodalite (Pink Angel) with different fluencies of fast neutrons in the Cd-shielded CLICIT facility of the Oregon State TRIGA reactor. In the absence of trapped argon, the upper intercept of a plot of $^{36}Ar/^{38}Ar$ against $^{37}Ar/^{38}Ar$ defines a relationship between ^{36}Ar and ^{38}Ar from the action of cosmic ray-induced secondary neutrons and mono-isotopic ^{36}Ar from ^{36}Cl decay. By combining data from two irradiations, the two contributions can be unambiguously distinguished. Figure 1 shows allowed combinations of $^{36}Cl/^{35}Cl$ and the product of cosmogenic secondary neutron fluence and ^{37}Cl cross section for each series. The intersection corresponds to $^{36}Cl/^{35}Cl = (1.9 \pm 0.5) \times 10^{-8}$ and $< \sigma_{37}.\Phi > = (1.1 \pm 0.8) \times 10^{-10}$.

The latter is in accord with the neutron fluence observed in CAIs in Allende [4]. The $^{36}Cl/^{35}Cl$ ratio is 3 orders of magnitude lower than the highest value inferred from ^{36}S excesses. If interpreted chronologically, i.e., as a closure age, it would correspond to a period of 3Ma or so of activity involving the precipitation of sodalite, which is consistent with I-Xe data [5]. Alternatively, the low ratio may represent ^{36}Ar loss in line with the low activation energy for Ar diffusion in sodalite. The presence of excess ^{36}Ar together with ^{36}S supports the idea that live ^{36}Cl was present in the sodalite, as opposed to the ^{36}S being inherited. The mechanism for producing ^{36}Cl several million years after the formation of the solar system is still unknown.

References: [1] Lin Y. et al. 2005. *Proceedings of the National Academy of Sciences* 102:1306–1311. [2] Hsu W. et al. 2006. *The Astrophysical Journal* 640:525–529. [3] Jacobsen B. et al. 2009. Abstract #2553. 40th Lunar and Planetary Science Conference. [4] Wasserburg G. J. et al. 2011. *Geochimica et Cosmochimica Acta*, in press. [5] Turner G. et al. *Meteoritics & Planetary Science* 44:A5255.